

Claims

What is claimed is:

1. A nitride light emitting device comprising:
5 a substrate;
a first nitride semiconductor stack formed above the substrate, the first nitride semiconductor stack having an epitaxial surface and a first rough surface, a distance from the epitaxial surface to the substrate being not less than a distance from the rough
10 surface to the substrate;
a nitride emitting layer formed on the epitaxial surface; and
a second nitride semiconductor stack formed on the nitride emitting layer.
- 15 2. The nitride light emitting device of claim 1 wherein the first nitride semiconductor stack comprises a nitride buffer layer formed on the substrate, and a first nitride contact layer formed on the nitride buffer layer.
- 20 3. The nitride light emitting device of claim 1 further comprising a first electrode formed above a first contact area of the first nitride semiconductor stack.
4. The nitride light emitting device of claim 3 further comprising a
25 first transparent conductive layer formed between the first contact area and the first electrode.
5. The nitride light emitting device of claim 3 further comprising a first transparent conductive layer formed on the first contact area
30 and the rough surface of the first nitride semiconductor stack.
6. The nitride light emitting device of claim 3 wherein a roughness of

the first contact area is not greater than a roughness of the first rough surface.

- 5 7. The nitride light emitting device of claim 1 further comprising a reverse tunneling contact layer formed on the second nitride semiconductor stack, the reverse tunneling contact layer and the second nitride semiconductor stack being formed by opposite types of materials.
- 10 8. The nitride light emitting device of claim 7 wherein the reverse tunneling contact layer has a super lattice structure.
9. The nitride light emitting device of claim 8 further comprising a second transparent conductive layer formed on the reverse
15 tunneling contact layer.
10. The nitride light emitting device of claim 1 wherein the second nitride semiconductor stack has a second rough surface and a second contact area.
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11. The nitride light emitting device of claim 10 further comprising a second electrode formed above the second contact area of the second nitride semiconductor stack.
- 25 12. The nitride light emitting device of claim 1 wherein the first rough surface of the first nitride semiconductor stack has a roughness between 3nm and 500nm.
13. The nitride light emitting device of claim 10 wherein the second
30 rough surface of the second nitride semiconductor stack has a roughness between 3nm and 500nm.

14. The nitride light emitting device of claim 4 wherein the first transparent conductive layer comprises at least one material selected from a group consisting of Al, Ti, Ti/Al, Cr/Al, Ti/Au, Cr/Au, Ni/Au, TiW, TiN, WSi, Au/Ge, indium tin oxide, cadmium tin oxide, antimony tin oxide, zinc aluminum oxide, and zinc tin oxide.
15. The nitride light emitting device of claim 5 wherein the first transparent conductive layer comprises at least one material selected from a group consisting of Al, Ti, Ti/Al, Cr/Al, Ti/Au, Cr/Au, Ni/Au, TiW, TiN, WSi, Au/Ge, indium tin oxide, cadmium tin oxide, antimony tin oxide, zinc aluminum oxide, and zinc tin oxide.
16. The nitride light emitting device of claim 9 wherein the second transparent conductive layer comprises at least one material selected from a group consisting of Ni/Au, NiO/Au, TA/Au, TiWN, TiN, indium tin oxide, cadmium tin oxide, antimony tin oxide, zinc aluminum oxide, and zinc tin oxide.
17. The nitride light emitting device of claim 1 wherein the substrate comprises at least one material selected from a group consisting of sapphire, CaN, AlN, SiC, GaAs, GaP, Si, ZnO, MgO and glass.
18. The nitride light emitting device of claim 1 wherein the first nitride semiconductor stack comprises at least one material selected from a group consisting of AlN, GaN, AlGa_N, InGa_N, and AlInGa.
19. The nitride light emitting device of claim 1 wherein the nitride emitting layer comprises at least one material selected from a group consisting of AlN, GaN, AlGa_N, InGa_N, and AlInGa_N.

20. The nitride light emitting device of claim 1 wherein the second nitride semiconductor stack comprises at least one material selected from a group consisting of AlN, GaN, AlGa_N, InGa_N, and AlInGa.
21. The nitride light emitting device of claim 2 wherein the first nitride contact layer comprises at least one material selected from a group consisting of AlN, GaN, AlGa_N, InGa_N, and AlInGa_N.
22. The nitride light emitting device of claim 1 wherein the first nitride semiconductor stack is N-type and the second nitride semiconductor stack is P-type.
23. The nitride light emitting device of claim 1 wherein the first nitride semiconductor stack is P-type and the second nitride semiconductor stack is N-type.
24. A nitride light emitting device comprising:
- a substrate;
 - a first nitride semiconductor stack formed above the substrate, the first nitride semiconductor stack having an epitaxial surface and a first rough surface, a distance from the epitaxial surface to the substrate being not less than a distance from the first rough surface to the substrate;
 - a nitride emitting layer formed on the epitaxial surface; and
 - a second nitride semiconductor stack formed on the nitride emitting layer and having a second rough surface.
25. The nitride light emitting device of claim 24 wherein the first nitride semiconductor stack comprises a nitride buffer layer formed on the substrate, and a first nitride contact layer formed on the nitride

buffer layer.

26. The nitride light emitting device of claim 24 further comprising a first electrode formed above a first contact area of the first nitride semiconductor stack.

27. The nitride light emitting device of claim 26 wherein the distance between the first contact area and the substrate is longer than the distance between the first rough surface and the substrate.

28. The nitride light emitting device of claim 26 wherein the distance between the first contact area and the substrate is less than the distance between the first rough surface and the substrate.

29. The nitride light emitting device of claim 26 wherein the distance between the first contact area and the substrate is equal to the distance between the first rough surface and the substrate.

30. The nitride light emitting device of claim 26 further comprising a first transparent conductive layer formed between the first contact area and the first electrode.

31. The nitride light emitting device of claim 24 further comprising a first transparent conductive layer formed on the first contact area and the rough surface of the first nitride semiconductor stack.

32. The nitride light emitting device of claim 24 wherein the second nitride semiconductor stack has a second contact area.

33. The nitride light emitting device of claim 32 further comprising a second electrode formed above the second contact area of the second nitride semiconductor stack.

34. The nitride light emitting device of claim 33 further comprising a second transparent conductive layer between the second contact area and the second electrode.
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35. The nitride light emitting device of claim 24 further comprising a reverse tunneling contact layer formed on the second nitride semiconductor stack, the reverse tunneling contact layer and the second nitride semiconductor stack being formed by opposite types of conductivity.
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36. The nitride light emitting device of claim 35 wherein the reverse tunneling contact layer has a super lattice structure.
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37. The nitride light emitting device of claim 24 further comprising a second transparent conductive layer formed on the second nitride semiconductor stack.
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38. The nitride light emitting device of claim 37 wherein the second transparent conductive layer has a second electrode.
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39. The nitride light emitting device of claim 24 wherein the second rough surface of the second nitride semiconductor stack has a roughness between 3nm and 500nm.
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40. The nitride light emitting device of claim 30 wherein the first transparent conductive layer comprises at least one material selected from a group consisting of Al, Ti, Ti/Al, Cr/Al, Ti/Au, Cr/Au, Ni/Au, TiW, TiN, WSi, Au/Ge, indium tin oxide, cadmium tin oxide, antimony tin oxide, zinc aluminum oxide, and zinc tin oxide.
41. The nitride light emitting device of claim 31 wherein the first

transparent conductive layer comprises at least one material selected from a group consisting of Al, Ti, Ti/Al, Cr/Al, Ti/Au, Cr/Au, Ni/Au, TiW, TiN, WSi, Au/Ge, indium tin oxide, cadmium tin oxide, antimony tin oxide, zinc aluminum oxide, and zinc tin oxide.

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42. The nitride light emitting device of claim 34 wherein the second transparent conductive layer comprises at least one material selected from a group consisting of Ni/Au, NiO/Au, Ta/Au, TiWN, TiN, indium tin oxide, cadmium tin oxide, antimony tin oxide, zinc
10 aluminum oxide, and zinc tin oxide.

43. The nitride light emitting device of claim 37 wherein the second transparent conductive layer comprises at least one material selected from a group consisting of Ni/Au, NiO/Au, Ta/Au, TiWN, TiN,
15 indium tin oxide, cadmium tin oxide, antimony tin oxide, zinc aluminum oxide, and zinc tin oxide.

44. The nitride light emitting device of claim 24 wherein the substrate comprises at least one material selected from a group consisting of sapphire, GaN, AlN, SiC, GaAs, GaP, Si, ZnO, MgO and glass.
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45. The nitride light emitting device of claim 24 wherein the first nitride semiconductor stack comprises at least one material selected from a group consisting of AlN, GaN, AlGaIn, InGaIn, and AlInGaIn.
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46. The nitride light emitting device of claim 24 wherein the nitride emitting layer comprises at least one material selected from a group consisting of AlN, GaN, AlGaIn, InGaIn, and AlInGaIn.

47. The nitride light emitting device of claim 24 wherein the second nitride semiconductor stack comprises at least one material selected from a group consisting of AlN, GaN, AlGaIn, InGaIn, and AlInGaIn.
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48. The nitride light emitting device of claim 25 wherein the first nitride contact layer comprises at least one material selected from a group consisting of AlN, GaN, AlGa_N, InGa_N, and AlInGa_N.
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49. The nitride light emitting device of claim 24 wherein the first nitride semiconductor stack is N-type and the second nitride semiconductor stack is P-type.
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50. The nitride light emitting device of claim 24 wherein the first nitride semiconductor stack is P-type and the second nitride semiconductor stack is N-type.
51. The nitride light emitting device of claim 24 wherein the second
- 15 rough surface is formed by performing a dry etching process.
52. The nitride light emitting device of claim 51 wherein the dry etching process is a sputtering etching, ion-beam etching, plasma etching, or inactive ion etching process.
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53. The nitride light emitting device of claim 24 wherein the second rough surface is an epitaxial surface.
54. A method for forming a nitride light emitting device comprising
- 25 following steps:
- (a) forming a substrate;
 - (b) forming a first nitride semiconductor stack above the substrate, the first nitride semiconductor stack having an epitaxial surface and a first rough surface, a distance from the
 - 30 epitaxial surface to the substrate being not less than a distance from the rough surface to the substrate;
 - (c) forming a nitride emitting layer on the epitaxial surface; and

(d) forming a second nitride semiconductor stack on the nitride emitting layer.

5 55. The method of claim 54 wherein step (b) comprises forming a nitride buffer layer on the substrate, and forming a first nitride contact layer on the nitride buffer layer.

10 56. The method of claim 54 further comprising forming a first electrode above a first contact area of the first nitride semiconductor stack.

15 57. The method of claim 54 further comprising forming a first transparent conductive layer between the first contact area and the first electrode.

58. The method of claim 54 further comprising forming a first transparent conductive layer on the first contact area and the rough surface of the first nitride semiconductor stack.

20 59. The method of claim 54 wherein a roughness of the first contact area is not greater than a roughness of the first rough surface.

25 60. The method of claim 54 further comprising forming a reverse tunneling contact layer on the second nitride semiconductor stack, the reverse tunneling contact layer and the second nitride semiconductor stack being formed by opposite types of materials.

30 61. The method of claim 60 wherein the reverse tunneling contact layer has a super lattice structure.

62. The method of claim 60 further comprising forming a second transparent conductive layer on the reverse tunneling contact

layer.

- 5 63. The method of claim 54 further comprising forming a second rough surface and a second contact area on the second nitride semiconductor stack.
- 10 64. The method of claim 63 further comprising forming a second electrode above the second contact area of the second nitride semiconductor stack.
- 15 65. The method of claim 54 wherein the first rough surface of the first nitride semiconductor stack has a roughness between 3nm and 500nm.
- 20 66. The method of claim 63 wherein the second rough surface is formed by performing a dry etching process.
- 25 67. The method of claim 66 wherein the dry etching process is a sputtering etching, ion-beam etching, plasma etching, or inactive ion etching process.
- 30 68. The method of claim 63 wherein the second rough surface is an epitaxial surface.
69. The method of claim 54 wherein the first rough surface is formed by performing a dry etching process.
70. The method of claim 69 wherein the dry etching process is a sputtering etching, ion-beam etching, plasma etching, or inactive ion etching process.
71. The method of claim 54 wherein the first rough surface is formed

by performing a wet etching process.